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ABSTRACT

Four different methods for attending to a lecture were studied: listening, listening with an outline, note-taking, and note-taking with an outline. Each method was designed to influence the learner's level of processing and, therefore, to effect the encoding and retrieval of information from a lecture. In addition, the effects of no review or review after a lecture and no review or review before a test were also studied. The experiment used an intentional learning paradigm. Comprehension was measured by multiple choice recognition and short-answer recall tests given three weeks after lecture instruction. Statistically significant findings provide evidence that the level of processing is an important variable in learning from lecture. Other findings, though not statistically significant, lend support to both the external storage hypothesis and the encoding specificity hypothesis, which are the two major theories that are used to explain why lecture notes or outlines may be advantageous. Implications of these findings are discussed. (Author/GK)

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Encoding and Retrieval of Information fror Lecture

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Abstract

Four different methods for attending to a lecture were studied (listening, listening with an outline, note-taking, note-taking with an outline). Each method was designed to influence the learner's level of processing and, therefore, to effect the encoding and retrieval of information from a lecture. In addition, the effects of no review or review after a lecture and no review or review before a test were also studied. The experiment used an intentional learning paradigm, with a 4(encoding method) x 2(no review vs. review after lecture) x 2(no review vs. review before test) between-subject design. Comprehension was measured by multiple choice recognition and short-answer recall tests given three weeks after lecture instruction. Statistically significant findings provide evidence that the level of processing is an important variable in learning from lecture. Other findings, though not statistically significant, lent support to both the external storage hypothesis and the encoding specificity hypothesis, which are the two major theories that are used to explain why lecture notes or outlines may be advantageous. Implications of these findings are discussed.

Trends in the Study of Instruction

From 1900-1955 behaviorism was the foundation upon which the practice of American education and the study of instruction was built (Strike, 1974). More recently the study of instruction has shifted to concerns about the cognitive processes of learners as they interact with the instructional material (Rothkopf, 1970; Resnick, 1981; Wittrock & Lumsdaine, 1977). To understand the effects of instruction upon comprehension and memory, we must understand how the learners use their cognitive processes to attend, select, and transform the nominal stimuli provided during instruction into functional, meaningful, internal representations. In this view, the learner's cognitive process mediates instructional stimuli and learning outcomes (Levie & Dickie, 1973). The mediating process paradigm (e.g., Anderson & Biddle, 1975; Paivio, 1971; Rohwer, 1973) adds new insight into the nature of the relationships between instructional stimuli and learner responses. The learner is recognized as playing an active mediational role in determining "what is processed, how it is processed, and therefore, what is remembered" (Rothkopf, 1976, p. 116).

The Mediating Process Paradigm and Berliner's Experiments

Berliner (1976) has recommended specifically that a mediating process paradigm be used to formulate research on instruction. Experiments using the mediating process paradigm were reported by Berliner (1971, 1972) who studied learning from lecture instruction. Berliner compared the mediational effects of inserting questions into lectures with those of instructions to students to take notes or merely to pay attention. On immediate and delayed tests, the group receiving questions and attempting answers during the lecture scored higher than the note-taking and paying attention groups. In addition, the note-taking group was superior in test performance to the group that only paid attention. It was concern about mediating processes and achievement in lecture instruction that gave rise to the present study.

The Encoding vs. External Storage Issue

Although we are far from a useful theory of note-taking during lecture (Faw & Walker, 1976), we can conceptualize the function of note-taking as a "process vs. product" dichotomy (Carrier & Titus, 1979; DiVesta & Gray, 1972; Faw & Walker, 1976). The encoding hypothesis (DiVesta & Gray, 1972; Howe, 1970a) postulates that note-taking aids the learner to process the lecture, while listening, into a personally meaningful form. The external storage hypothesis (Miller, Galanter, & Pribram, 1969) postulates that note-taking transforms the lecture into a product for the learner's later review and further learning.

There has been agreement that both encoding and external storage are important. However, there remains some disagreement about the relative importance of the encoding and external storage hypotheses. While some researchers (e.g., Fisher & Harris, 1973; Carter & VanMatre, 1975) have contended that the external storage function of note-taking exceeds the encoding function in facilitating lecture learning, several experimental studies (e.g., Annis & Davis, 1975; DiVesta & Gray, 1972; Howe, 1970b) have shown greater facilitative effects for the encoding functions of note-taking.

Misconceptions about encoding. The inconsistent data that relate to the encoding vs. external storage issue may be due to misconceptions about encoding. Methodological problems can occur as a function of these misconceptions. Encoding must be thought of as a complex process variable. One would ask different questions about encoding depending on which aspects of the process are of interest. For example, questions could be asked about the encoding strategy (e.g., listening or note-taking) during a lecture. But one might also raise questions about the function of a review of lecture information that occurs immediately after the lecture. After-lecture review may be conceptualized as a part of the encoding process, as proposed by Fisher and Harris (1973). Thus, an after-lecture review, as distinguished from a before-test review would be related to encoding issues and not issues about external storage.

A simultaneous testing of the encoding and external storage hypotheses can be based on the paradigm proposed by Carter and Van Matre (1975). They specify the encoding phase as attending lecture and participating in immediate review. And then they specify the phase of instruction concerned with external storage as made up of a delayed review and a test. Unfortunately, Carter and Van Matre did not conceptualize encoding in terms of depth of processing (Craik & Lockhart, 1972). Furthermore, they did not report statistically significant differences between the delayed test scores of a note-taking group and its control. This kind of difference is a necessary condition to provide support for the external storage hypothesis (Miller et al., 1960). Instead, in their study, they combined the immediate and delayed test scores of their subjects. Improvements in design and analysis can be made, while still using the paradigm of Carter and Van Matre, to study the encoding and external storage hypotheses in learning from lecture.

Questions Related to Encoding and Retrieval in Lecture Learning

The goal of a lecture is student learning. Thus, it is desirable to study how students can learn more effectively from a lecture. From the literature reviewed, two important questions seem to arise: (1) What attending strategies (or orienting tasks) generate effective encoding during a lecture so that comprehension is enhanced; and (2) what is the influence of review processes on encoding and retrieval of lecture information when review occurs immediately after a lecture or just before a test.

Previous studies have not yet provided satisfactory answers to these two questions. Further study of encoding and retrieval in lecture learning is, therefore, called for.

The Present Experiment, Hypotheses, and Predictions

The present experiment was designed to examine the effects of the following three variables on learning from lectures: (1) encoding, (2) after-lecture review, and (3) before-test review.

There is evidence that outline facilitates encoding and retrieval in prose learning (Glynn & DiVesta, 1977; Staley & Wolfe, Note 1). In this study an outline was used to facilitate encoding of the lecture and for augmenting the usual listening and note-taking treatments. The encoding variable was operationalized into the following four arbitrarily ordered levels (Craik & Lockhart, 1972): (1) listening < (2) listening with lecturer's outline < (3) note-taking < (4) note-taking with lecturer's outline. The outline helped order these conditions in terms of a continuum based on hypothesized depth of processing.

To further explore the process of encoding, an after-lecture review variable with no review and review levels was incorporated in the design of this experiment. After-lecture review involved further processing of the materials to a deeper level (Craik, 1973). The concern for depth or levels of processing during encoding was incorporated into this design not only in terms of the encoding variable with its four levels (listening, listening and outline, note-taking, note-taking and outline) but also in terms of the after-lecture review variable with its two levels (no review vs. review). Statistical significance on the encoding variable, the after-lecture review variable, and their (possible) interaction were predicted. The specific order of the four levels of the encoding variable would have to be determined by post hoc statistical tests, although they were hypothesized to be ordered by the levels of processing required for learning, and therefore, were predicted to order similarly on the learning measure. It was hypothesized that the review condition would exceed the no review condition for the after-lecture review variable.

Further, a before-test review variable with no review and review levels was also incorporated in the design of this experiment. The before-test review variable was designed to obtain data to test the external storage hypothesis. Statistical significance for the before-test review was predicted, with review hypothesized to exceed no review. Specifically, a statistically significant (encoding) x (before-test review) interaction involving the note-taking and note-taking with outline treatments of the encoding variable would provide strong support for the external storage hypothesis.

In addition, this study was designed to yield data about whether the encoding specificity hypothesis (Tulving & Thomson, 1973) prevalent in prose learning, is applicable in learning from lecture. The encoding specificity hypothesis in the lecture context leads to a prediction that retention would be facilitated the most when the cues presented at retrieval (e.g., outline) are the same as those used during encoding. A statistically significant 3-way interaction in which subjects in the listening with outline and note-taking with outline conditions show superior preformance when in the after-lecture review and before-test review conditions would provide strong support for the encoding specificity hypothesis.

Method

Subjects

Subjects were 134 undergraduate volunteers from two educational psychology and two introductory psychology classes at The University of Arizona. They were asked to participate in both the learning and testing phase of the experiment. The majority of them received extra credit in their courses for participating in the experiment.

Materials

The materials for this experiment consisted of a lecture, accompanying instructional materials, and test instruments. The lecture was delivered live, following a well-prepared and organized set of notes on the topic of concept learning (adapted from Ellis, 1978) and specifically designed for this study.

Subjects attended to the lecture according to the instructions they were given. There were four specific instructions designed to affect encoding:

1. Listen to the lecture and give it your full attention;

2. Listen to the lecture. Give it your full attention and follow the lecture using the outline you have been given;

3. Listen to the lecture. Give it your full attention and take notes the way you usually do;

4. Listen to the lecture. Give it your full attention and take notes the way you usually do, but use the outline to help you follow the lecture and organize your notes.

The outlines for encoding treatment 2(listening and outline) and encoding treatment 4(note-taking and outline) were identical.

Further, half the subjects in each of the four encoding treatments were given instructions to review the information obtained in the lecture immediately after the lecture. The subjects read instructions requesting that they review the lecture mentally (encoding treatment 1); mentally with the outline used during the lecture (encoding treatment 2); or that they review the lecture with their notes (for encoding treatments 3 and 4). The subjects not engaged in review had an alternative assignment.

The four different encoding instructional conditions and the two review conditions yielded eight different lecture encoding treatments. Subjects in each treatment group received instructional booklets informir them what to do during and after the lecture.

Comprehension testing involved a multiple choice recognition test of 20 questions and a short-answer recall test of 10 questions. The multiple choice test was composed of knowledge level questions. The short-answer test was composed of half knowledge level and half application questions. Items on both tests were drawn evenly from all parts of the lecture.

Design and Procedure

The experiment featured a 4(encoding) x 2(after-lecture review) x 2(before-test review) between-subject design (Winer, 1971). Four levels of encoding (listening, listening with outline, note-taking, note-taking with outline) were factorially combined with two levels of after-lecture review (no review vs. review) and two levels of before-test review (no review vs. review). Thus, the design yielded 16 independent cells, each of which ultimately contained six subjects that had been randomly assigned.

The lecture, which constituted the stimulus material in this experiment, was conducted in a lecture hall, where classes usually met. Two lecture occasions were needed to process all the subjects. All subjects arrived at the lecture hall during the first five minutes of the class hour. At the entrance of the lecture hall, each subject was given one of the eight different encoding booklets which had been randomly mixed. Each booklet was sealed but was separated into Part A and Part B. The front cover of the booklet had instructions that informed subjects not to open the booklet until asked to do so.

At 10 minutes past the hour, the experimenter announced that there was a special lecture on "Concept Learning" by a guest speaker. Subjects were informed that they would be given a comprehension test three weeks later to see how well they understood the lecture. All subjects were then requested to open Part A of the encoding booklet and attend to the lecture only according to the method described in their booklet. Subjects who were to take notes (encoding treatments 3 and 4) wrote on their encoding booklets. The lecture, which lasted for about 35 minutes, was delivered by a female graduate student skilled in educational psychology and communications. Thus, the subjects were in an experiment designed to be similar to their usual class meeting and were asked to encode a live lecture, as they might usually do in college courses. The experiment conformed to an intentional learning paradigm since subjects were aware during the lecture that a memory test would be administered later (Wickelgren, 1978) and because of the explicit instructions for encoding the lecture (McLaughlin, 1965).

Immediately after the lecture, the experimenter asked all subjects to open Part B of their encoding booklets, which presented two different review instructions. One-half of the subjects of each of the four encoding instructional groups were requested to review the lecture mentally (encoding treatment 1); mentally with their outline (encoding treatment 2); or by using their notes (encoding treatments 3 and 4). The other half of the subjects were given a task to prevent review. They were asked to complete a rating assignment on four abstracts of research articles selected from the Journal of Educational Psychology. Both the subjects in the review and the no-review conditions were asked to spend at least five minutes, but were allowed up to 10 minutes to complete their assignment. All subjects were asked to write their names on the encoding booklets and return them when they had completed their assignment. Further, subjects were asked to not discuss the lecture with one another, and all were reminded to come back in three weeks to take the comprehension test.

Prior to the testing day, all subjects were informed by mail to return for the comprehension test. During the testing day, all the subjects that came back for testing were assigned, by random alternation, to either a review or no review group, respectively, before the test. Subjects in the review group who took notes (encoding treatments 3 and 4) received their encoding booklets and they were given written instructions requesting that they review their notes for 10 minutes before the test. Subjects in the review group that did not take notes (encoding treatments 1 and 2) did not receive their encoding booklets. They were given written instructions to review the lecture mentally (encoding treatment 1) or mentally with the aid of the outline used during lecture (encoding treatment 2) for 10 minutes before the test. Subjects in the no review group were given the test immediately. The tests were untimed. Most subjects took about 30 minutes to complete the two tests. All subjects were given the short-answer recall test after they had finished the multiple choice recognition test.

As mentioned above, the lecture was given twice, to approximately 60% and 40% of the subjects each time. The lectures were separated by five days. Thus, the testing sessions for these subjects were also separated by five days. The procedures used during each of the two learning and testing sessions were identical.

Results

Subject Mortality

The number of subjects in the two sessions were: 130 and 95, respectively, for the learning phases; and 59 and 85, respectively, for the testing phase. In total there were 225 subjects who participated in the learning phase. Only 144 subjects returned three weeks later for the testing session. Consequently, the numbers of subjects in the 16 cells of the experiment were unequal, ranging from 6-11. Therefore, the internal validity of the experiment may be threatened due to differential "mortality," a problem identified by Campbell and Stanley (1966). Thus, the four encoding and two after-lecture conditions were examined to inquire if mortality was systematic or random. Using chi-square, it was found that the frequency of missing subjects in any of the cells in the design was not greater than could be expected by chance (df = 3, $p < .75$).

Scoring

There were 20 multiple choice questions making up the recognition test. One point was assigned to each correct answer. The maximum score was, therefore, 20. Subjects obtained a range of scores from 2-16. For the short-answer recall test the highest possible score was also 20. The test consisted of 10 questions for which each correct answer could receive up to two points. The range of scores was from 0-16.

Numbers of Subjects and Descriptive Data

Of the 144 subjects who took the comprehension tests, four were eliminated because they failed to respond to the short-answer recall test and, therefore, received a score of zero. Additional subjects were randomly eliminated, until six subjects were categorized in each of the 16 cells. This was done to have equal numbers of subjects per cell, a desirable condition for analysis of variance. Table 1 presents the means and standard deviations for the 96 subjects who made up the final sample for analysis. In Table 2 the means and standard deviations are presented for the subjects on the mutliple choice recognition and short-answer recall tests, grouped according to the three factors that are of interest in the study--encoding, after-lecture review, and before-test review.

Insert Tables 1 and 2 about here

Reliability

The reliability of the two tests was computed by means of coefficient alpha (Cronbach, 1951). The reliability coefficients were low for both tests, although acceptable for research purposes.

Analysis of Variance

A 4(encoding) x 2(after-lecture review) x 2(before-test review) between-subject fixed effect model ANOVA was conducted using scores from the recognition and recall tests. Table 3 presents the ANOVA results for recognition and recall performance.

Insert Table 3 about here

Recognition. The analysis of variance for recognition scores (see Table 3) yielded three statistically significant effects: A main effect for the encoding variable, $F(3,80) = 4.29$, $p < .007$; a main effect for before-test review, $F(1,80) = 12.32$, $p < .001$; and an interaction effect between (after-lecture review) x (before-test review), $F(1,80) = 4.65$, $p < .034$.

Since the encoding factor was found to be statistically significant, the means of the four encoding groups (see Table 2) were analyzed by the Newman-Keuls test with alpha set at the .05 level. Results indicated three statistically significant differences with the following ranked pattern: Listening ($\overline{X}$ = 8.13) = note-taking ($\overline{X}$ = 8.79) < note-taking and outline ($\overline{X}$ = 10.50); listening ($\overline{X}$ = 8.13) < listening and outline ($\overline{X}$ = 9.54). Figure 1 depicts the trend of the four encoding group means on the recognition test.

Insert Figure 1 about here

The Newman-Keuls test was also used to analyze the (after-lecture review) x (before-test review) interaction. Results indicated two statistically significant differences: No review after-lecture and no review before-test ($\overline{X}$ = 8.71) = review after-lecture and no review before-test ($\overline{X}$ = 8.04) < review after-lecture and review before-test ($\overline{X}$ = 10.83) Figure 2a depicts the (after-lecture review) x (before-test review) interaction that occurred when the recognition test scores were analyzed. It is a disordinal pattern of interaction.

Insert Figure 2 about here

Recall. The recall test scores also yielded statistically significant findings. The analysis of variance for recall scores (see Table 3) yielded three statistically significant main effects: Encoding, $F(3,80)$ = 8.29, $p < .001$; after-lecture review, $F(1,80)$ = 5.69, $p < .019$; and before-test review, $F(1,80)$ = 23.97, $p < .001$. In addition, the (encoding) x (after-lecture review) interaction, $F(3,80)$ = 2.30, $p < .094$, approached but did not attain conventional significance levels.

Since the main effect of encoding was statistically significant, the four means of the four encoding groups (see Table 2) were analyzed with the Newman-Keul's test with alpha set at the .05 level. Results indicated three statistically significant differences with the following ranked patterns: Listening ($\overline{X}$ = 3.83) = listening and outline ($\overline{X}$ = 4.63) < note-taking ($\overline{X}$ = 4.71) < note-taking and outline ($\overline{X}$ = 6.96). Figure 1 depicts the trend of the four encoding group means on the free recall test.

The interaction between after-lecture review and before-test review on the recall measure was not statistically significant, as it was with the recognition test. Interestingly, Figure 2b depicts an ordinal pattern of (after-lecture review) x (before-test review) interaction for the recall measure. Inspection of Figure 2a and 2b, simultaneously, shows that there is a similarity in the trends of the (after-lecture review) x (before-test review) interaction for both recognition and recall.

Discussion

Recognition vs. Free Recall

The present findings provide further support for the proposal (e.g., James, 1890; Kintsch, 1970) that there are important qualitative differences between recognition and recall. A contemporary conception is that recall involves a search process and a decision process which adjudicates on the appropriateness of what has been retrieved, whereas recognition primarily involves only the decision process. This conception of the information processing requirements of the two types of activity suggests that recall tests might be more difficult than recognition tests. The data in this study support that interpretation.

Encoding

The present findings produced strong evidence (see Table 3) for the levels of process hypothesis (Craik & Lockhart, 1972; Cermak & Craik, 1979). First, the main effect of encoding was statistically significant for both the recognition and recall. Specifically, note-taking and outline produced deeper level of encoding, for both recognition and recall, as compared to the other three methods of attending to the lecture (listening, listening and outline, note-taking). Interestingly, the data suggest that when recognition tests are used as a criterion for learning, the listening with outline treatment is superior to the note-taking treatment, indicating a deeper level of encoding. On the recall test listening with an outline is almost equal to the effects of the note-taking treatment. The trend suggested from these data is that with improved outlines and training in using outlines it is likely that listening to a lecture and following an outline is superior to the treatment of note-taking as an effective encoding method while attending a lecture.

The after-lecture review factor showed statistical significance when the short-answer recall test was analyzed. Thus, it is believed that after-lecture review involved further encoding of the lecture information to a deeper level (Craik, 1973). The belief that encoding of the lecture information at a deeper level took place was further evident by an (encoding) x (after-lecture review) interaction for the data on the recall test. However, this interaction was not quite significant at conventional levels, $p < .09$.

External Storage

The present findings did not produce unequivocal evidence (see Table 3) for the external storage hypothesis (Miller et al., 1960). Although the before-test review factor showed statistical significance on both the recognition and recall tests, there was no statistically significant (encoding) x (before-test review) interaction found. Overall, the review before-test condition yielded superior performance on the comprehension tests than did the no review before-test condition (see Table 2). But it is not clear that the superior performance on recognition and recall tests was, in fact, due to the effect of reviewing notes. High test performance was also evidenced by the mental review with outline treatments on the recognition test, which had no notes to use. And even mental review for the listening only treatments seemed somewhat successful. Thus, a case can be made that it is just before-test review that is helpful, rather than before-test review with notes. However, as the data in Figure 1 indicate, note-taking with an outline yielded the highest test scores on both the recognition and free recall tests. Moreover, listening with an outline was a superior treatment to just listening. These data concerning reviews with notes and outlines and their effect on test performance do provide some further evidence for the external storage hyothesis.

Encoding Specificity

The 2(after lecture: no review vs. review) x 2(before test: no review vs. review) matrix yielded a statistically significant disordinal interaction when the recognition test was analyzed (see Figure 2a). When review occurs both after-lecture and before-test it results in superior recognition test performance when compared with the other three treatments. While there was no statistically significant (after-lecture review) x (before-test review) interaction on the short-answer recall measure, Figure 2b depicts an ordinal (after-lecture review) x (before-test review) interaction pattern for the recall test performance. The interaction trend shown in Figure 2a and 2b is similar for both recognition and recall. It is not clear that the superior recognition and recall test performance is, in fact, due to review of the notes and outlines at both after-lecture and before-test. That is, there is no statistically significant (encoding) x (after-lecture review) x (before-test review) three-way interaction involving the outline conditions of the encoding variable. This three-way interaction would have provided strong support for the encoding specificity hypothesis.

However, Figure 1 indicates that note-taking with an outline yielded the highest test performance for both recognition and recall tests and that the listening with an outline condition was superior to the listening only condition on the recognition test. These data and the similarity of the interactional trends of (after-lecture review) x (before-test review) on both recognition and recall tests (see Figure 2a and 2b) provide some evidence for the encoding specificity hypothesis (Tulving & Thomson, 1973).

Implications

Using the mediating process paradigm as Berliner did (1971, 1972, 1976) to formulate research on lecture learning, the present study simultaneously tested the encoding, external storage, and encoding specificity hypotheses using the paradigm of Carter and Van Matre (1975). Statistically significant data provide (1) confirmatory evidence for the levels of processing hypothesis and (2) partial evidence for the external storage hypothesis and the encoding specificity hypothesis.

What is the meaning of these results? First, and most important, we have learned that we can process our lecture information at a deeper level of cognition by use of a strategy combining two encoding methods.

namely, listening with outline or note-taking with outline during the lecture and reviewing immediately after a lecture. Second, a (delayed) before-test review facilitates retrieval, and further learning, and thus provides evidence that a deeper level of processing of the lecture information has occurred. Third, review at both after-lecture and before-test with the same outline (cue) facilitates retrieval. This is the encoding specificity principle that implies that cues that are present at encoding and also presented at retrieval facilitates retrieval. The data in this study suggest ways to improve learning from lecture. If lecturers were to use outlines and require after-lecture as well as before-test reviews, learning would be facilitated.

Reference Note

1. Staley, R. K., & Wolf, R. I. *The outline as an encoding and retrieval cue in learning from prose*. Paper presented to the American Educational Research Association, San Francisco, 1970.

References

Anderson, R. C., & Biddle, W. B. On asking people questions about what they are reading. In G. H. Bower (Ed.), The psychology of learning and motivation (Vol. 9). New York: Academic Press, 1975.

Annis, L., & Davis, J. K. The efforts of encoding and an external memory device on notetaking. Journal of Experimental Education, 1975, 44, 44-46.

Berliner, D. C. Aptitude treatment interaction in two studies of learning from lecture instruction. Berkeley, Calif.: Far West Laboratory for Educational Research & Development, 1971 (ERIC Document Reproduction Service No. ED 046 249).

Berliner, D. C. The generalizability of aptitude treatment interaction across subject matter. Berkeley, Calif.: Far West Laboratory for Educational Research & Development, 1972 (ERIC Document Reproduction Service No. ED 062 642).

Berliner, D. C. Impediments to the study of teacher effectiveness. Journal of Teacher Education, 1976, 27, 5-13.

Campbell, D. T., & Stanley, J. D. Experimental and quasi-experimental designs for research. Chicago: Rand McNally & Co. 1966.

Carrier, C. A. & Titus, A. The effects of notetaking: A review of studies. Contemporary Educational Psychology, 1979, 4, 299-314.

Carter, J. F., & Van Matre, N. H. Notetaking versus note having. Journal of Educational Psychology, 1975, 67, 900-904.

Cermak, L. S., & Craik, F. I. M. (Eds.). Levels of processing in human memory. Hillside, N.J.: Lawrence Erlbaum Associates, 1979.

Craik, F. I. M. A "levels of analysis" view of memory. In P. Pliner, J. Krames, & T. Alloway (Eds.), Communication and affect. Academic Press: London, 1973.

Craik, M. I. F., & Lockhart, R. S. Levels of processing: A framework for memory research. Journal of Verbal Learning and Verbal Behavior, 1972, 11, 671-684.

Cronbach, L. J. Coefficient alpha and the internal structure of tests. Psychometrica, 1951, 16, 297-334.

DiVesta, F. J., & Gray, S. Listening and notetaking I. Journal of Educational Psychology, 1972, 63, 8-14.

Ellis, H. E. Fundamentals of human learning, memory, and cognition. Dubuque, Iowa: Brown, 1978.

Faw, H. W., & Walker, T. G. Mathemagenic behaviors and efficiency in learning from prose. Review of Educational Research, 1976, 46, 321-325.

Fisher, J. I., & Harris, M. B. Effects of notetaking and review on recall. Journal of Educational Psychology, 1973, 65, 321-325.

Glynn, S. M., & DiVesta, F. J. Outline and hierarchical organization as aids for study and retrieval. Journal of Educational Psychology, 1977, 69, 89-95.

Howe, M. J. A. Notetaking strategy, review, and long term retention of verbal information. Journal of Educational Research, 1970, 63, 285. (a)

Howe, M. J. A. Using students' notes to examine the role of the individual learners in acquiring meaningful subject matter. Journal of Educational Research, 1970, 64, 61-63. (b)

James, W. Principles of psychology, Vol. 1. New York: Holt, 1890

Kintsch, W. Models for free recall and recognition. In D. A. Norman (Ed.), Models of human memory. London: Academic Press, 1970.

Levie, W. J., & Dickie, K. E. The analysis and application of media. In R. M. W. Travers (Ed.), Second handbook of research on teaching. Chicago: Rand McNally, 1973

McLaughlin, L. "Intentional" and "incidental" learning in human subjects. Psychological Bulletin, 1965, 63, 359-376.

Miller, G. A., Galanter, E., & Pribram, K. H. Plans and the structure of behavior. New York: Holt, Rinehart & Winston, 1960.

Paivio, A. Imagery and verbal processes. New York: Holt, Rinehart & Winston, 1971.

Resnick, L. B. Instructional psychology. In M. R. Rosenzweig & L. W. Porter (Eds.), Annual review of psychology, Palo Alto, Calif: Annual Review, Inc., 1981, 32, 659-704.

Rohwer, W. D., Jr. Elaboration and learning in children and adolescents. In H. W. Reese (Ed.), Advances in child development and behavior (Vol. 8). New York: Academic Press, 1973.

Rothkopf, E. Z. The concept of mathemagenic activities. Review of Educational Research, 1970, 40, 325-336.

Rothkopf, E. Z. Writing to teach and reading to learn: A perspective on the psychology of written instructions. In N. L. Gage (Ed.), The psychology of teaching methods. 75th Yearbook of the National Society for the Study of Education, Pt. I. University of Chicago Press, 1976.

Strike, K. A. On the expressive potential of behaviorist language. American Educational Research Journal, 1974, 11, 103-120.

Tulving, E., & Thomson, D. M. Encoding specificity and retrieval processes in episodic memory. Psychological Review, 1973, 80, 453-473.

Wickelgren, W. Learning and memory. New York: Academic Press, 1978.

Winer, B. J. Statistical principles in experimental design (2nd ed.). New York: McGraw-Hill, 1971.

Wittrock, M. C., & Lumsdaine, A. A. Instructional psychology. In M. R. Rosenzweig, & L. W. Porter (Eds.), Annual review of psychology. Palo Alto, California: Annual Reviews, Inc., 1977, 28, 417-459.

Table 1

Means and Standard Deviations on the Recognition and Recall Tests for the 16 Groups of Subjects

Encoding	After-Lecture Review	Before-Test Review	N	Recognition $\overline{X}$	Recognition S	Recall $\overline{X}$	Recall S
Listening	No	No	6	9.00	2.76	3.17	1.84
		Yes	6	7.00	2.10	4.50	3.83
	Yes	No	6	7.00	1.28	3.33	1.03
		Yes	6	9.50	2.07	4.33	1.37
Listening	No	No	6	9.17	2.32	3.67	2.16
& Outline		Yes	6	9.67	1.03	5.33	1.75
	Yes	No	6	7.17	1.15	3.00	2.10
		Yes	6	12.17	2.64	6.50	1.64
Notetaking	No	No	6	7.67	2.58	3.17	1.94
		Yes	6	10.33	2.34	5.00	1.90
	Yes	No	6	7.83	.98	3.33	2.50
		Yes	6	9.33	3.39	7.33	4.72
Notetaking	No	No	6	9.00	2.37	4.17	1.47
& Outline		Yes	6	10.50	3.15	6.50	2.07
	Yes	No	6	10.17	3.60	6.67	3.01
		Yes	6	12.33	2.88	10.50	2.81

Table 2

Means and Standard Deviations for the Respective Levels of Encoding, After-Lecture Review, and Before-Test Review Effects on the Recognition and Recall Tests

		Recognition		Recall	
Effects	N	$\overline{X}$	S	$\overline{X}$	S
Encoding					
Listening	24	8.13	2.29	3.83	2.95
Listening & Outline	24	9.54	2.55	4.63	2.28
Notetaking	24	8.79	2.57	4.71	3.28
Notetaking & Outline	24	10.50	3.05	6.96	3.24
After-Lecture Review					
No Review	48	9.04	2.48	4.44	2.32
Review	48	9.44	2.99	5.63	3.46
Before-Test Review					
No Review	48	8.38	2.35	3.81	2.34
Review	48	10.10	2.88	6.25	3.37

Table 3

ANOVA for Recognition and Recall

Effects	Recognition F	Recognition df	Recognition p	Recall F	Recall df	Recall p
Encoding (E)	4.29	(3,80)	<.007	7.29	(3,80)	<.001
After-Lecture Review (ALR)	.65	(1,80)	NS	5.69	(1,80)	<.019
Before-Test Review (BTR)	12.32	(1,80)	<.001	23.97	(1,80)	<.001
E X ALR	.66	(3,80)	NS	2.20	(3,80)	<.094
E X BTR	1.16	(3,80)	NS	.77	(3,80)	NS
ALR X BTR	4.65	(1,80)	<.034	1.68	(1,80)	NS
E X ALR X BTR	2.08	(3,80)	NS	.32	(3,80)	NS

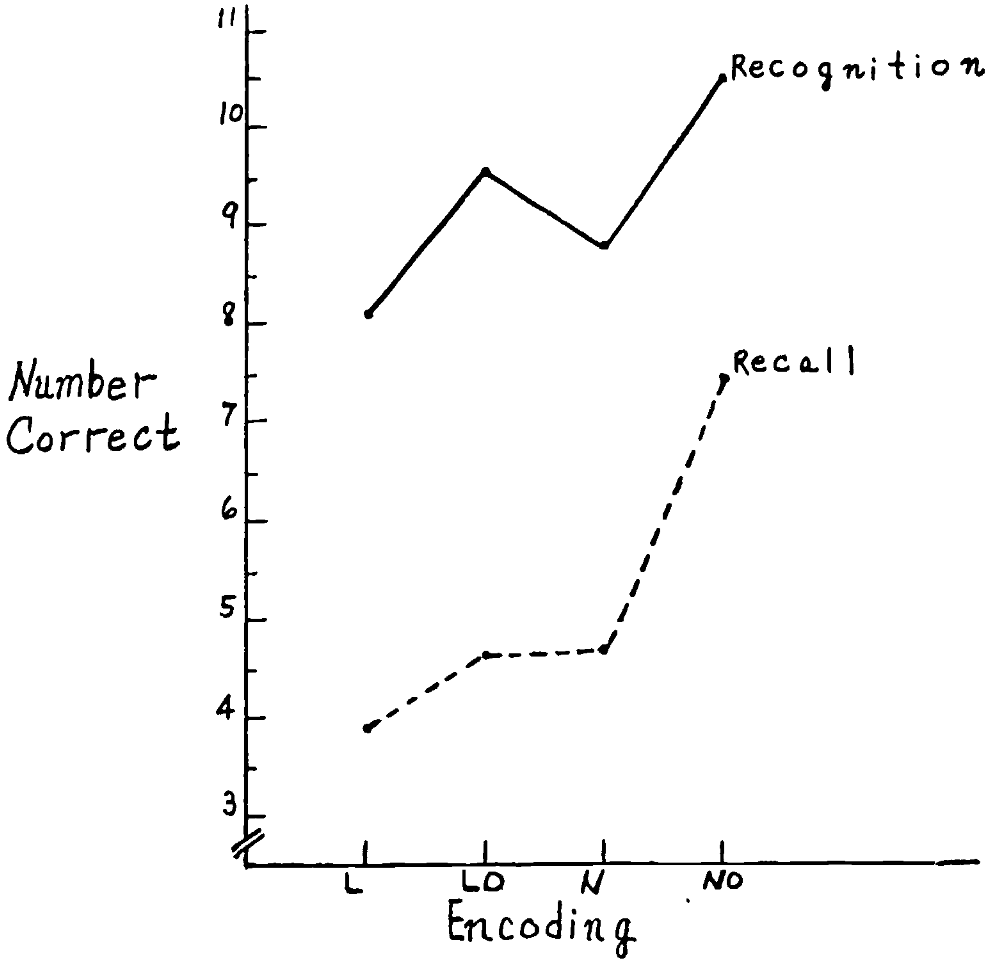

Figure 1. Trends for the four encodir groups (listening = L; Listening & Outline = LO; Note-taking = N; Note-taking & Outline = NO) on recognition and recall.

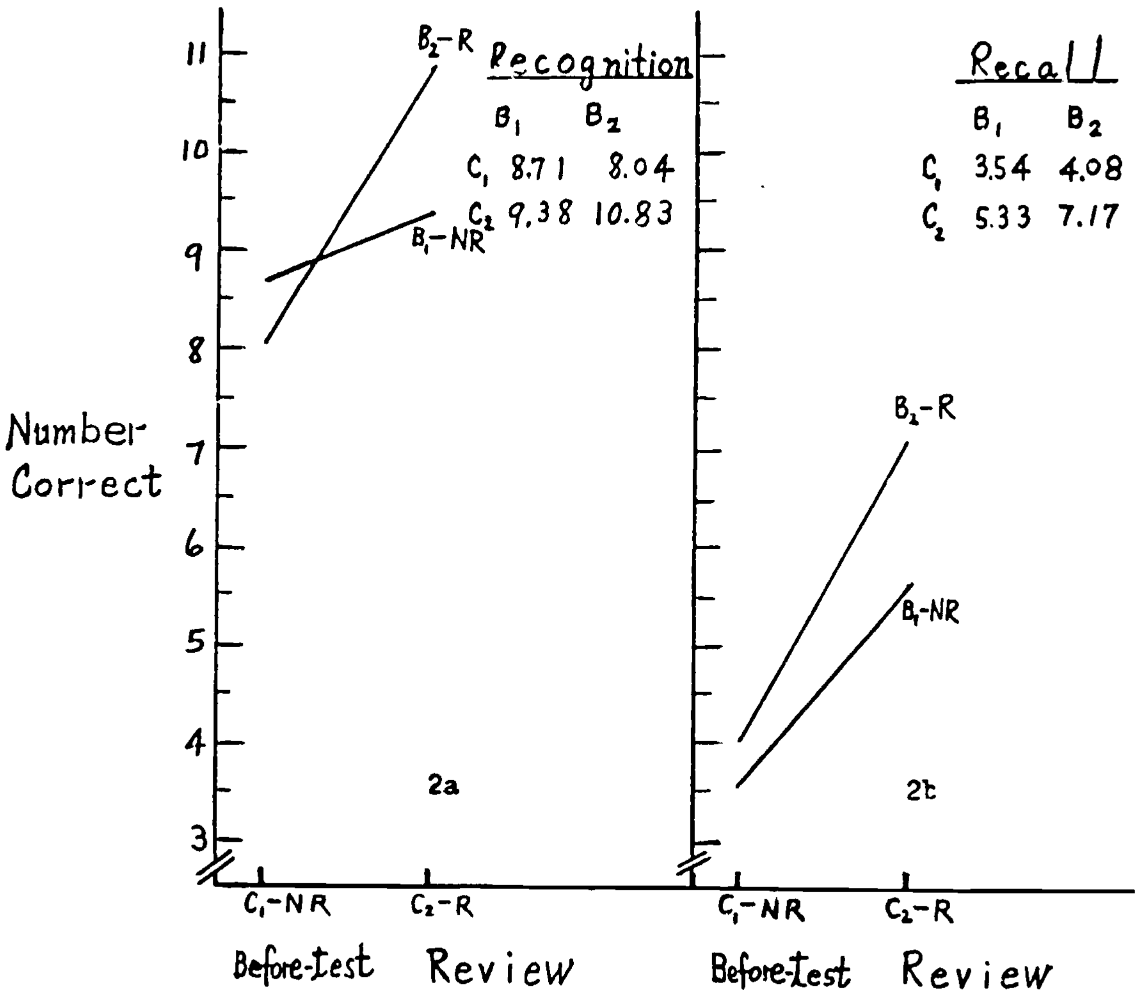

Figure 2. Disordinal interaction of (after-lecture review) x (before-test review) for recognition test scores (Figure 2a); and ordinal interaction of (after-lecture review) x (before-test review) for recall test scores (Figure 2b). B = after-lecture review, C = before-test review, NR = no review, R = review.